Information-seeking behaviors of medical students: a classification of questions asked of librarians and physicians*

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To solve a problem, a person often asks questions of someone with more expertise. This paper reports on a study of the types of questions asked and how the experts are chosen. In the study, sixty-three first-year medical students responded to clinical scenarios, each describing a patient affected by a toxin and asking questions concerning the identity of the toxin and its characteristics. After answering those questions, the students were asked to imagine that they had access to a medical reference librarian and an internist specializing in toxicology. The students then generated two questions for each expert about each clinical scenario. Each question was categorized according to the type of information requested, and the frequency of each type of question was calculated. The study found that students most often asked for the identification of the toxin(s), references about the scenario, or the effects of the toxin; an explanation of the patient's symptoms; or a description of the appropriate treatment. Students were more likely to address questions on the identity of the toxin and references to the hypothetical librarian; they were more likely to ask the internist for explanations of the symptoms and descriptions of the treatment. The implications of these results for the design of information and educational systems are discussed.

When faced with a problem, a person may be able to solve it using his or her knowledge of the domain or may need additional information from an external source. When students are introduced to a new domain, it is unlikely that they have enough personal knowledge to solve realistically complex problems in that domain. When they seek additional information about the problem from external sources, they will ask questions—an epistemic function of question asking [1]. Such questions may be addressed to formal sources, such as databases and the literature, or to individuals who have some expertise in the domain. Very little is known about the types of questions asked by novices in order to solve the typical problems in a domain of interest. After reviewing the theoretical and empirical background on question asking as an expression of an information need, this article will describe a study of questions asked by medical stu-

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dents presented with clinical problems in the domain of toxicology.

BACKGROUND

In 1960, Berlyne developed a psychological theory for question asking, postulating an "epistemic drive" [2]. His theory was based on stimulus-response data and held that question asking was one type of epistemic behavior; that is, "behavior that augments knowledge" [3]. Cognitive consistency theorists generally rejected the notion of a unitary epistemic drive but accepted the view that "a person behaves in a way that maximizes the internal consistency of his [or her] cognitive system" [4]. In this view, a person asks questions in an attempt to confirm an idea consistent with his or her cognitive system or to disprove an inconsistent idea. These general theories of question asking were related to specific questions in specific contexts by Kearsley, who suggested that individuals ask specific questions to "fill 'gaps' in a cognitive model" of a particular concept [5]. This theme appears in the information retrieval literature as the system user's anomalous state of knowledge (ASK); that is, a state in which gaps, uncertainty, or some element of incoherence exists [6–7].

In the most direct application of these theories to an information-retrieval setting, Brooks et al. analyzed "unstructured problem statements" from individuals addressing queries to an online bibliographic retrieval system [8]. They then created association maps based on the words in the problem statements; these association maps represented users' ASKs. The ASKs then were classified based on two features: the extent to which concepts were interconnected (i.e., whether a map represented a dense web of associated concepts or a very sparse set of loosely connected concepts) and the number of single-node structures in the map. Based on these two features, ASKs were placed along a spectrum ranging from "well-defined topic and problem" to "topics and problems not well-defined; topics often unfamiliar" [9].

Other studies have focused on categorizing the types of questions people ask. Using a Piagetian classification of question functions, Davis found that both children and adults most often asked for explanations of other people's behaviors [10], while Meyer and Shane found that older children most often asked factual questions [11]. Good and Slavings compared questions asked in math and language-arts classrooms and found that, among the oldest children (grade 12), questions about classroom procedures and facts were common in both classrooms; on-task questions to attract attention were common in the math classrooms; and requests for explanations were common in language-arts classrooms [12]. In an experimental study where subjects were asked to learn a card game, Fishbein et al. found that almost half the questions were about the game procedures rather than definitions of concepts or the point values associated with particular cards [13]. White took a somewhat different approach in studying the questions asked of reference librarians in order to compare the question-oriented and needs-oriented approaches to the reference interview [14]. Clients' original question statements most often included the subject of the query and the characteristics of the information sought, such as the time frame or format.

Several studies have focused on the information needs of physicians or medical students. Covell et al. categorized the questions raised by physicians in interviews immediately following patient visits [15]. Forty percent of the 269 questions were questions of fact, 43% were questions of medical opinion, and the remaining 17% asked for nonmedical information. In a study of questions posed during clinical teaching, Osheroff et al. classified the clinical questions according to the subject of the request and the type of response required [16]. Sixty-one percent of the questions asked for information about a specific patient, 25% asked about a disease therapy, 7% asked about a differential diagnosis, and 16% asked about other clinical issues.† Seventy-three percent of the responses asked for facts; 23% asked for a synthesis of patient and medical knowledge; 11% asked for speculation, opinion, or synthesis; and 3% asked for other types of responses. In a study of MEDLINE access in a clinical setting, Haynes et al. found that trainees and attending staff cited questions concerning therapy as the reason for conducting an online search [17]. They also sought information for case overviews, prognosis, and etiology. Although each of these studies casts light on the information-seeking behaviors of physicians or medical students, the results are difficult to synthesize into an overall pattern.

As the design and provision of information systems and services become more user centered, it is clear that a better understanding is needed of users' information-seeking behaviors. One aspect of these behaviors is the questions asked of those with more expertise—expertise in either the domain or the process of information seeking. The study reported here begins to explore these question-asking behaviors in the context of medical education by analyzing the questions asked by medical students about clinical scenarios in toxicology.

† The codes used were not mutually exclusive, so the total is greater than 100%.

THE STUDY

This study primarily addressed two research questions. First, it examined the types of questions students asked when they were presented with a clinical scenario. In this situation, they were trying to solve a problem in a domain in which they had little knowledge. Given the opportunity to ask questions to help solve the problem, what types of questions would they ask? Analysis of the function of these questions permits these students' information needs to be categorized. Second, the study compared the questions students would ask of physicians (i.e., experts in the domain) with those they would ask of librarians (i.e., experts in the process of information seeking). The results of this comparison have implications for the design of educational and information systems and services.

Method

The study reported here is part of a larger study of medical students' use of online factual databases in microbiology, pharmacology, and toxicology. A sample of participants for this study was selected from the 1991 entering class of the School of Medicine at the University of North Carolina at Chapel Hill. After eliminating those who had an advanced degree in science or an undergraduate degree in microbiology, seventy students were selected randomly and invited to participate in the study. Of those students, sixty-three accepted (a response rate of 90%).

The three-hour assessment period was divided into four parts: first, the students responded to six clinical scenarios in microbiology; then responded to the same scenarios with the aid of INQUIRER, a database of facts and concepts in microbiology [18]; then responded to six clinical scenarios in toxicology; and then generated questions they wanted to ask about four of the scenarios (Appendix A). Students were asked to generate questions for only four of the scenarios because of time constraints. The order of the two domains—microbiology and toxicology—was selected randomly for the first group assessment and alternated for the remaining assessment sessions.

The results reported here are based on the questions generated by the students concerning the toxicology scenarios in response to the following instructions.

- Imagine that you had a medical reference librarian at your disposal. What two questions would you ask this individual to investigate for you?
- Consider that an internist specializing in toxicology has some time to spend with you to help you better understand what is happening to the patient(s) described in the scenario. What two questions would you pose to this individual?

Table 1
Categories of student questions in the medical domain

I.	Identification
	A. Personal object
	B. Impersonal object
	1. Toxin(s)*
	2. References/published articles*
	3. Chemical composition/chemical groups*
	C. Action
	1. Effects of the toxin(s)*
	2. Tests/methods of differentiation*
II.	Definition
III.	Description (nonstate)
IV.	Placing
	A. Time
	B. Space
V.	Explanation
	A. Categorization
	B. Effect
	1. Explanation of treatment*
	2. Prognosis*
	C. Cause
	1. Explanation of symptoms*
VI.	Process
	A. Associations/relationships between entities*
	B. Route of exposure*
	C. Treatment*
	D. Follow-up on case or patients*
	E. Environmental effects of the toxin*
	F. Other processes*
VII.	Degree
VIII.	State
IX.	Kind
X.	Manner

* Subcategories added for this study.

The students generated 1,082 questions, an average of 17 questions each. (Some questions were subdivided during the categorization process, resulting in more questions than the 16 requested from each student.)

Based on the question's form (rather than its content), each was categorized according to the type of information requested. The question categories originally developed by Robinson and Rackstraw were used as the basis for the categorization scheme [19]. Their categorization scheme was customized to the medical domain, as illustrated in Table 1.

The categorization process was not straightforward, due to the ambiguity of natural language. For instance, the question "What does orthostatic hypotension mean?" could be a request for the definition of the term or for an explanation of the significance of the symptom in relation to the case being examined. Two methods were used to help resolve this type of ambiguity and increase the reliability of the question categorizations. First, following the lead of prior investigators, the expected answer of each question was considered, as well as the literal wording of the question [20–21]. By taking into account the most likely potential answers to a particular question, possible categories for that question were constrained.

Second, the categorization for each question was reviewed by at least two members of the research team. If there was disagreement, a third reviewer made the call.

Certain student-generated questions were eliminated from the analysis because they were literally identical to questions accompanying the scenarios. For example, in response to the scenario given in Appendix A, one student asked, "How would you treat a comatose patient?" This question corresponds closely with stimulus question 3. After the elimination of all such questions, 948 questions remained for the analysis.

The frequency of each category of question was calculated, as well as the frequency with which each type of question was asked of librarians or physicians. Three null hypotheses were tested: that there was no association between particular categories of questions and individual students (i.e., there were no individual differences in the types of questions generated); that there was no association between particular categories of questions and the scenarios to which they were addressed; and that there was no association between particular categories of questions and the type of expert to whom they were addressed. The X^2 statistic was considered for this analysis but may not be valid when a high proportion of the expected frequencies for individual cells are less than five, as was the case in the tables being analyzed here. In such a situation, Fisher's exact test would be the preferred alternative, but it is not computationally feasible for these tables. Instead, the distribution curve of the expected values was smoothed by adding a constant (0.5) to each cell, as discussed by Agresti [22], resulting in an adjusted X^2—a more conservative test of statistical significance than the X^2 statistic alone.

RESULTS

The results from this study are described in four sections. First, the frequencies for each category of question are reported. Next, the differences in categories of questions generated by particular students and for particular problems are analyzed. Finally, the results pertaining to the question of primary interest will be presented: the categories of questions addressed to a hypothetical physician versus those addressed to a hypothetical librarian.

Category frequencies

The 948 questions included in the analysis were categorized as shown in Table 2. As can be seen from a comparison with Table 1, certain categories of questions were not generated by these students. They include identification of personal objects, nonstate descriptions, placement in time, explanation through categorization, state descriptions, kinds, and manner. (The reader is referred to Robinson and Rackstraw for further discussion of these question types [23].) The question types that *were* generated by students are discussed below.

The first category is "identification of impersonal objects." These questions are generally "what" questions, and the student is expecting the name of a particular entity or a list of entities as a response. For example, one student asked, "What toxins can cause the above symptoms?" The student was expecting a list of possible toxins as a response. More than 500 of the students' questions fell into this major category—56% of all the questions asked. This major category was subdivided into three subcategories: identification of the toxin(s), identification of references or articles related to the case, and identification of the chemical composition of the toxin or the chemical group of which it was a member.

The most common type of identification question, asked 308 times, concerned the responsible toxin(s). This subcategory was divided further on the basis of the other information given in the question. For example, if a student asked the question cited in the previous paragraph, it was categorized as a question concerning the identification of the toxin based on the symptoms in the scenario. Symptoms, environmental factors such as the patient's workplace, or a combination of symptoms and environmental factors were used most often in questions concerning the identity of the toxin(s), accounting for 86% of all the questions in this subcategory.

Identification of references or articles related to the case was also a common question, asked 105 times. This subcategory was divided further on the basis of the type of information being requested. For instance, one student asked, "Is there a book outlining symptoms of poisonings?" This question was categorized as identification of a reference about symptoms. Symptoms and environmental factors were again common topics for these questions, accounting for 61% of this subcategory.

Finally, students asked questions related to identification of the chemical composition of the toxin(s) or the chemical group. An example of the former is "What are the contents (chemical) of the insect repellent and insecticide spray used by the people at the picnic?" An example of the latter is "What are the different chemical groups of pesticides?" These types of questions were asked twenty-four times.

Students also asked questions concerning the identification of actions or events. They asked for identification of the effects of the toxin(s) in seventy questions. These included questions concerning the signs, symptoms, and diseases caused by the toxin(s) and the body systems affected by the toxin(s). For example, one student asked, "What symptoms are associ-

Table 2
Types of questions asked

Type/category of questions asked	Subcategory	No. of questions asked of librarian	No. of questions asked of physician	Totals for subcategories/ categories
Identification				
Toxins	general	0	5	5
	by symptoms	71	38	109
	by environmental factors	84	11	95
	by symptoms + env. factors	42	19	61
	by epidemiology	35	2	37
	other	1	0	1
	Total: Toxins	233	75	308
References/related articles	general	11	0	11
	for definitions	4	0	4
	about symptoms	29	0	29
	about environmental factors	17	0	17
	about symptoms + env. factors	18	0	18
	about epidemiology of toxin	19	0	19
	about treatment	5	0	5
	about diagnosis/testing	2	0	2
	Total: References	105	0	105
Chemical composition/groups		21	3	24
Effects of the toxin	signs and symptoms	22	30	52
	diseases	2	1	3
	systems affected	2	13	15
	Total: Effects	26	44	70
Tests/methods of differentiation		5	20	25
Total: Identification		390	142	532
Definition		32	15	47
Placing: Space (location of toxin)		7	0	7
Explanation/mechanisms				
By cause	explanation of symptoms	29	159	188
By effect	explanation of prognosis	2	16	18
	explanation of treatment mechanism	0	5	5
	Total: By effect	2	21	23
Other (env. factors)		0	2	2
Total: Explanation/mechanisms		31	182	213
Process				
Treatment		12	67	79
Associations	between environment and toxin	3	8	11
	between symptoms and toxin	6	5	11
	between symptoms	8	18	26
	Total: Associations	17	31	48
Route of exposure		4	8	12
Follow-up of cases/patients		3	1	4
Environmental effects		3	0	3
Other processes		1	2	3
Total: Process		40	109	149
Total		500	448	948

ated with ingestion of these products?" Students also asked what tests could be used to identify a toxin or to differentiate one candidate toxin from another. These types of diagnosis-related identification questions were asked twenty-five times. An example is, "What other tests can be done to determine the origin of the toxicity?"

The second major category of questions is "definition" questions. These are generally "what is" questions, asking for the meaning of a particular term. Definition questions were asked forty-seven times by these students, accounting for 5% of the questions asked. Most of these questions related to unfamiliar terms from the scenario. For example, one student asked, "What is *tachycardia*?" Questions explicitly asking for a term's meaning, such as, "What does *opsoclonus* mean?" were placed in this category; in other words, the researchers did not assume that questions asking for meaning were requests for an explanation of the significance of a particular symptom.

Seven questions concerned the location of a toxin and were categorized as "placement" questions. These are "where" questions, asking for a location in space. An example of this type of question is "Where could these agents have come from?"

More than 200 questions asked for an explanation of some aspect of the scenario. Most of these were phrased as "how" or "why" questions and concerned the mechanism of action involved in the case. One hundred eighty-eight questions (89% of the category) asked for an explanation of one or more symptoms. For example, one student asked, "How did the toxins affect the eyes?" Because these questions were related to a prior event—the poisoning—they were classified as questions asking for an explanation based on the cause of the event. Questions relating to the significance of particular symptoms (e.g., "What is the significance of erythrocyte cholinesterase?") also were included in this subcategory. Most of the remaining questions in this category asked for an explanation concerning a future event, such as the treatment suggested or the prognosis for the patient. An example of such a question is "How does the treatment reduce the half life of the toxin?"

Almost 150 of the questions (16% of the total) asked for the description of a process. In general, these are "how" questions, asking for a description of a procedure of some kind. The most frequently asked subcategory of process questions related to the patient treatment. For example, one student asked, "How does one treat low erythrocyte cholinesterase levels?" A second subcategory of process questions concerned associations or relationships between various entities in the scenario: between the environment and the toxin, between the symptoms and the toxin, or among two or more symptoms. Forty-eight questions concerned associations. One example is "Is her numbness related to her blurred vision?" The other types of process questions related to the route of exposure to the toxin(s), follow-up of previous cases or the current patient(s), and environmental effects of the toxin(s).

Differences in questions asked across students

The null hypothesis—that there was no association between the categories of questions asked and the individual students—was tested, and a statistically significant difference was found (continuity-adjusted $X^2 = 3{,}365.241$, with 1,984 *df*, $P < 0.000$). This result implies that there were differences in the questions asked by the individual students.

Based on the frequencies with which the different types of questions were asked by different students and the value of the cell X^2 statistics in the frequency analysis, several examples were selected to illustrate the question-generation patterns of these students. It should be noted that because of the nature of the X^2 statistics, question categories with very high overall frequencies (e.g., explanation of symptoms) are unlikely to have high X^2 values in this table. The low number of questions asked by each student in relation to the high frequency of the category rules out an effect on the overall X^2. At the other extreme, categories with very low frequencies (e.g., effects of the toxin in terms of diseases) are not discussed in this section, because a single student-generated question can result in a relatively high cell X^2.

In some cases, a student focused on a particular type of question. For example, half of one student's eighteen questions asked for definitions of terms. In other cases, a small number of students generated a high proportion of the questions asked in one category. For example, a single student's questions accounted for more than one third of the questions asking for general references, and another student's questions accounted for more than one fourth of the questions on the association between the toxin and the patient's symptoms.

Differences in questions asked across scenarios

Of the 948 questions analyzed, 910 were distributed fairly evenly across the four scenarios (231 for scenario A, 252 for B, 230 for C, and 197 for D). The remaining thirty-eight questions concerned scenarios E and F; although the students were asked to generate questions for the first four scenarios, they were not precluded from using the other two scenarios. For scenario A, 27 different categories of questions were generated; scenario B, 27 categories; scenario C, 28; and scenario D, 23. The null hypothesis—that there was no association between the categories of questions asked and the different scenarios—was tested, and a statistically significant difference was found (continuity-adjusted $X^2 = 400.913$, with 160 *df*, $P < 0.000$), implying that there were differences in the questions asked across scenarios.

Based on the frequencies with which the different types of questions were asked concerning the different scenarios and the value of the cell X^2 statistics in the frequency analysis, a few anomalies most likely accounted for the association represented by the overall X^2 value. An analysis of these anomalies indicated that the content of the scenarios or the questions accompanying them led students to inquire about certain aspects of the case. Illustrative examples for each scenario are described here. Scenario A (Appendix A) accounted for 65% of the questions asking for references about environmental factors; its emphasis on the patient's workplace probably led students to ask for references about the hazards associated with that environment. For scenario B, in which five sentences

described the setting while only two mentioned symptoms, requests for the identification of the toxin by environmental factors were very common, while requests for the identification of the toxin by symptoms were infrequent. For scenario C, which concerned toxic exposure of workers in a pesticide or insecticide plant, questions asking for identification of the toxin based on epidemiological information were common.

Scenario D gave detailed information about the patient's symptoms but very little information about the environment in which she was exposed to the toxin. In response to scenario D, students frequently asked for identification of the toxin based on symptoms and references about the symptoms, but they rarely asked for identification of the toxin based on environmental factors. Also, because technical names were used for many of the symptoms described in this scenario, students often asked for definitions of these terms. The high frequency of requests for tests and other methods of differentiating the toxin from similar agents can be explained by the fact that Scenario D asked the students whether urinalysis or fecal analysis would be helpful in identifying the poison. One surprising finding was that, although this scenario asked students for a treatment for this poisoning, the students did not emphasize this point in the questions they generated.

Differences in questions asked of physicians and librarians

Of the 948 questions analyzed, 500 would have been posed to a hypothetical medical reference librarian, and 448 would have been posed to a hypothetical internist specializing in toxicology (Table 2). The null hypothesis—that there was no association between the types of questions asked and the type of expert to whom they were addressed—was tested, and a statistically significant difference was found (continuity-adjusted $X^2 = 418.155$, with 32 *df*, $P < 0.000$), indicating that there was a difference between the types of questions addressed to physicians and those addressed to librarians. Based on the frequencies with which questions were asked of each hypothetical expert and the value of the cell X^2 statistics in the frequency analysis, a few types of questions most likely accounted for the association represented by the overall X^2 value.

The questions asked more frequently of the hypothetical librarian than of the internist concerned identification of toxin(s), particularly by environmental factors or by epidemiology; identification of references, particularly references about symptoms, environmental factors, or the epidemiology of the toxin; and identification of the chemical composition or chemical group of the toxin. With regard to the toxin identification questions, an example of the first type is "What toxic agents could be present in a plastic factory?" An example of the second type is "I'd ask for a history of health complaints and symptoms of workers in synthetic fiber and plastic factories." With regard to the reference questions, students not only addressed more questions to the hypothetical librarian on the identification of references and related articles, but, of the 105 questions in this category, none was addressed to the hypothetical physician. Finally, 88% of the questions on identification of chemical composition or chemical group were addressed to the hypothetical librarian.

The questions asked more frequently of the hypothetical physician than of the librarian concerned identification of tests or methods of differentiation, explanation of symptoms or a prognosis, and description of the treatment process. Eighty percent of the twenty-five questions asking about tests or methods of differentiating toxins were addressed to the hypothetical physician. Requests for an explanation of symptoms contributed more to the X^2 value than did any other subcategory. The students asked 188 of these questions, and 85% of them were addressed to the hypothetical physician. Only eighteen questions asked for an explanation of the prognosis; all but two of these were addressed to the hypothetical physician. Almost eighty questions asked how to treat the patient in the scenario; of these, 85% were directed to the hypothetical physician.

DISCUSSION

The results are discussed in the same order in which they were presented.

Overall frequency of question categories

Although students generated questions in half of Robinson and Rackstraw's question categories [24], more than 75% of their questions fell into just five subcategories: identification of toxins, identification of references, identification of the effects of the toxins, explanation of the symptoms, and treatment processes. One common theme runs through the majority of these questions: the students are interested in the clinical aspects of the case. The identification questions and the requests for an explanation of the system focus on diagnosis. Many of these questions demonstrate that the students expect to provide a diagnosis based on two aspects of the scenario: the signs and symptoms presented by the patient and the environment in which the patient was exposed to the toxin. The remaining questions, those asking how to treat the patient, complete the clinical cycle. This finding is consistent with the clinical nature of the scenarios themselves.

The predominance of identification questions suggests that one gap in a first-year student's knowledge lies in naming objects and actions of interest. In the domain of toxicology, the relevant objects and actions include toxic agents, the effects of those agents, and references pertaining to symptoms and environmental factors associated with toxic exposure. The large number of questions asking for an explanation of the symptoms or a description of treatment procedures suggests that students are interested in the mechanisms of toxic agents and their antidotes. The small number of definition questions suggests either that students know the meanings of most of the medical terms used in the scenarios or that they are generally not concerned with their vocabulary deficiencies.

Differences between students

Because first-year students vary in their levels of personal knowledge, it is not surprising that the categories of questions generated also varied by student. There are several plausible explanations for the observed patterns in students' question-asking behaviors. One possibility is that some students used the first few questions they generated as templates for additional questions, merely customizing them to fit the new scenario. Another possibility is that some students had preconceptions that the information available from librarians and physicians falls within a narrow range, and they therefore limited their questions to that range. In either case, it appears that a group of students is willing to ask a broad range of questions concerning clinical scenarios, but individual students tend to limit their queries to a small number of categories.

Differences across scenarios

Results of this study indicate that students' questions about a clinical case are influenced by the information provided in the scenario describing the case. If the scenario emphasizes the environment in which the case occurs, students are likely to ask questions concerning the environment. If the scenario emphasizes the patient's symptoms, students are likely to ask questions concerning those symptoms. These results are consistent with Briggs' finding that questions generated about a word-processing task predominantly concerned process descriptions, focusing on how to perform the task [25]. This finding can be used to advantage in an educational setting by presenting students with a wide variety of case descriptions, each emphasizing a different aspect of the case and thereby drawing the students' attention to that aspect of the case.

Differences in questions to the two experts

In general, students asked the hypothetical physician questions on the clinical aspects of the scenario (e.g., explanation of symptoms, prognosis, and treatment) and asked the hypothetical librarian more general questions concerning the identification of the toxin and references relevant to the scenario. Questions asking for an explanation of the symptoms or prognosis, the identification of tests or methods for differentiating toxins, or a description of the appropriate treatment require an answer from someone with a high level of clinical expertise; they seldom could have been answered by someone with only a general understanding of the toxic agent and its effects. The students were probably correct in their estimation that these questions are best addressed to a practicing physician who can interpret them in the context of a particular case. While these results are generally not surprising, the data are puzzling in certain respects.

First, it is somewhat surprising that no student asked the hypothetical physician for references to relevant articles. One partial explanation for this pattern is that the students were so accustomed to asking librarians for guidance in identifying potential references that they directed all of the questions on references to the hypothetical librarian, not realizing that a much more varied set of questions—including factual questions—could be addressed appropriately to a librarian. It is also possible that these students did not expect a physician to be aware of the latest literature related to a particular toxin, its symptoms, or the settings in which it can affect humans. A third possibility is that students valued the physician's clinical expertise so highly that they did not want to "waste" any of the physician's time on nonclinical questions. This issue certainly warrants further study.

A second and somewhat similar surprise in the data was the small number of questions addressed to the hypothetical physician concerning the identity of the salient toxin. Although the pattern was less striking than in the case of requests for references, students might have used similar reasoning in addressing most of these questions to the hypothetical librarian. The setting of the study itself also could have had an effect. Approximately half of the students used an online database earlier in the assessment period to answer similar identification questions in microbiology. Even though this database was not developed or used by the library, students' prior experience with online library catalogs and bibliographic databases may have led them to associate the identification of a pathogen with their use of the library. An additional interpretation could be that the questions addressed to the hypothetical physician required professional judgment, while the questions asked of the hypothetical librarian required statements of fact. How-

ever, there is nothing in the data that supports this conclusion. In the categories of questions addressed to both types of expert, the wording of questions addressed to the physician could not be distinguished from the wording of those addressed to the librarian. Also, it can be argued that identification of the responsible toxin in a realistically complex scenario requires professional judgment, not just factual information.

Finally, it was somewhat surprising that students asked the hypothetical librarian how to treat the patient. For these questions, not only is clinical expertise required to provide an answer, but, also, medical reference librarians would be cautious in responding due to liability concerns related to the unauthorized practice of medicine [26–27]. In an educational setting such as the one in this study, where the patients are hypothetical, it seems less likely that liability would be an issue. Nevertheless, it was not expected that any treatment questions would be addressed to the hypothetical librarian.

CONCLUSION

Most of the 948 questions generated by first-year medical students in response to clinical scenarios in toxicology asked for the identification of the toxin(s), the identification of relevant references, the identification of the effects of the toxin(s), an explanation of the patient's symptoms, and a description of how to treat the patient. Students addressed questions on the identification of the toxin(s), references, and the chemical composition or group of the toxin(s) to a hypothetical librarian, and they asked for identification of diagnostic tests, explanations of the patient's symptoms and the prognosis, and a description of the appropriate treatment from a hypothetical physician. Differences in the types of questions asked for different scenarios and by different students also were found, as expected.

Although the selection of students from the entering class and the development of the clinical scenarios were well controlled, interpretation of the results must take into account some limitations of the study. First, the research design did not take into account the variation in the number of questions asked per student. Each student was asked to generate sixteen questions, but the actual number of questions generated ranged from ten to twenty-one, averaging seventeen per student. Because there were differences in the types of questions asked by individual students, it is possible that some types of questions were underrepresented and others were overrepresented. However, in a natural setting, there would probably be even more variation in the number of questions asked. The second limitation of the study is that it was confined to one domain—toxicology—and to an educational setting. The results should not be generalized to other domains, even within the field of medicine, and the results might not be applicable even to researchers or clinicians, even in toxicology. Finally, interpretation of students' reasons for generating particular questions would be enhanced if data concerning their motivations were gathered in future studies.

The findings do have important implications for the provision of library services to medical students. They support the traditional library role of providing bibliographic references relevant to clinical cases, particularly references concerning symptoms and environmental factors that can affect a case. In addition, the results suggest that libraries should acquire or build information systems that will help students identify the pathogens relevant to a particular case. These students expected that the librarian could answer questions concerning the identity of a toxin in a particular setting; it is likely that they will expect librarians to play a similar role for the identification of other such agents.

The results also have important implications for the design of other information systems supporting medical education. These students asked questions concerning the explanation of the symptoms in a case, what tests or other methods could be used to distinguish among candidate toxins, what the prognosis was, and how to treat the patient. These types of questions most often were addressed to the hypothetical physician—an expert rarely available to medical students in the early years of their education. Online systems that address these types of questions would augment students' educational experiences.

Because of the limitations of this study, additional research is needed into the types of questions that medical students ask. Analysis of these questions can be used to understand the information needs of medical students and thus to design information and educational services and systems that effectively support their learning.

REFERENCES

1. KEARSLEY GP. Questions and question-asking in verbal discourse: a cross-disciplinary review. J Psychol Res 1976; 5(4):355–75.
2. BERLYNE DE. Conflict, arousal, and curiosity. New York: McGraw-Hill, 1960.
3. IBID., 262.
4. NEWCOMB TM. Introduction. In: Abelson RP, Aronson E, McGuire WJ, Newcomb TM et al. Theories of cognitive consistency: a sourcebook. Chicago: Rand McNally, 1968: xv.
5. KEARSLEY, op. cit., 364.
6. BELKIN NJ. Anomalous states of knowledge as a basis for information retrieval. Can J Inf Sci 1980 May;5:133–43.
7. BELKIN NJ, ODDY RN, BROOKS HM. ASK for information

retrieval: part 1. Background and theory. J Doc 1982 Jun; 38(2):61–71.
8. BROOKS H, ODDY RN, BELKIN NJ. Representing and classifying anomalous states of knowledge. In: MacCafferty M, Gray K, eds. The analysis of meaning. Informatics 5: proceedings of a conference held by the Aslib Informatics Group and the BCS Information Retrieval Specialist Group, March 26–28, 1979, The Queen's College, Oxford. London: Aslib, 1979:227–38.
9. IBID., 237.
10. DAVIS EA. The form and function of children's questions. Child Dev 1932 Mar;3(1):57–74.
11. MEYER WJ, SHANE J. The form and function of children's questions. J Genet Psychol 1973 Dec;123:285–96.
12. GOOD TL, SLAVINGS RL. Male and female student question-asking behavior in elementary and secondary mathematics and language arts classes. J Res Childhood Educ 1988 spring/summer;3(1):5–23.
13. FISHBEIN HD, VAN LEEUWEN R, LANGMEYER D. Teacher versus learner controlled instruction: question-asking and comprehension. Br J Educ Psychol 1992 Feb;62(1):126–31.
14. WHITE MD. Different approaches to the reference interview. In: Katz B, Bunge CA, eds. Rothstein on reference. . .with some help from friends. (The reference librarian, no. 25/26). New York: Haworth Press, 1989:631–46.
15. COVELL DG, UMAN GC, MANNIN PR. Information needs in office practice: are they being met? Ann Intern Med 1985; 103:596–9.
16. OSHEROFF JA, FORSYTHE DE, BUCHANAN BG, BANKOWITZ RA ET AL. Physicians' information needs: analysis of questions posed during clinical teaching. Ann Intern Med 1991; 114:576–81.
17. HAYNES RB, MCKIBBON KA, WALKER CJ, RYAN N ET AL. Online access to MEDLINE in clinical settings: a study of use and usefulness. Ann Intern Med 1990;112:78–84.
18. FRIEDMAN CP, TWAROG R, YOUNGBLOOD PL, DE BLIEK R ET AL. Computer databases as an educational tool in the basic sciences. Acad Med 1990;65:15–6.
19. ROBINSON WP, RACKSTRAW SJ. A question of answers, volume 1. London: Routledge and Kegan Paul, 1972.
20. IBID.
21. OSHEROFF, op. cit.
22. AGRESTI A. Categorical data analysis. New York: Wiley, 1990:249–50.
23. ROBINSON, op. cit.
24. IBID.
25. BRIGGS P. Do they know what they're doing? An evaluation of word-processor users' implicit and explicit task-relevant knowledge, and its role in self-directed learning. Int J Man Mach Stud 1990 Apr;32(4):385–98.
26. ALLEN LS. Legal and ethical considerations in providing health information. In: Rees AM, ed. Developing consumer health information services. New York: Bowker, 1982:42–8.
27. GROEN F. Provision of health information has legal and ethical aspects. Can Libr J 1983 Dec;40(6):361.

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APPENDIX A

Sample scenario

A normally healthy 35-year-old female worker in a synthetic fiber and plastic factory complained of general weakness, dizziness, and headache. Nausea and vomiting occurred. Her pulse rate was over 100. The first time this occurred it was attributed to a weekend party where she had overindulged. A week later she suffered the same symptoms, which progressed to tachycardia and tachypnea, then dyspnea and bradycardia, and she was near loss of consciousness. Her skin color was excellent. It must be assumed that the toxic agent responsible is at her work site.

1. Symptoms indicate that the victim was not receiving adequate oxygen. What possible toxic agent could be responsible?
2. If there was a lack of oxygen, why was no cyanosis seen?
3. If the patient had become comatose, what treatment procedures could have been instituted? Give rationale.